Marked-up Copy of Substitute Specification

Attorney Docket No.: 1028443-000074

APPARATUS AND METHOD IN A PAPER MACHINE AND A PAPER MACHINE

TECHNICAL FIELD RELATED TO THE INVENTION

The object of the invention is an apparatus and a method in a paper machine and a paper machine according to the preambles of the independent claims presented below. The invention especially relates to an edge support of a forming table in a paper machine.

PRIOR ART

In a paper machine equipped with a flat forming table i.e. in a so-called Fourdrinier machine the stock layer flowing from the head box to the planar forming table must be supported by the edges. At this stage the fibre concentration of the stock is low, typically 0.3-0.8 weight-%, therefore its behaviour resembles the behaviour of water. Supporting of the edges is required to prevent the stock layer from running off the sides outside the wire area. Furthermore, without edge support the running off the sides causes flaws in the end product that are visible far away from the edge of the web, i.a. basis weight deficit, orientation discrepancy and tensile strength discrepancy.

In figures 1a and 1b a conventional edge support of a forming table according to prior art is shown. In figure 1a there is shown a head box 1, fabric edge curler 2, an edge wave 3 indicated schematically by arrows and a deckle rail 4. In figure 1b there is further shown a wire 5 and a wearing plastic lip 15 used for sealing. Edge support according to prior art is thus usually comprised of a short rod-shaped deckle rail 4 on the wire and fabric edge curler 2 to be performed thereafter, in which with the aid of formed pieces the edge section of the wire 5 is lifted off the table. Drawbacks of a solution of this type are for example:

1. Fabric edge curler is located further out than the line of the deckle rail, in which case the ending of the rail causes a significant edge disturbance and a stock deficit, as material leaks out toward the edge of the wire.

2. Fabric edge curler reflects edge leakage inwards as an edge wave causing a downstream broadening edge disturbance in the machine direction.

3. No dewatering is directed at the fabric edge curler area, as the wire is not in contact with the table. This increases the stock imbalance of the edge area and impairs controllability.

4. Fabric edge curler functions differently when the driving parameters of the machine vary, such as the slice opening, machine speed and the underpressure of the dewatering. The disturbances caused by the fabric edge curler are thus difficult to remove in a machine that runs different grades.

5. The fabric edge curler stretches the wire causing a greater mechanical strain and thus faster wearing of the wire.

6. The deckle rail gets easily dirty, wherefore separate and often complicated washing solutions of the deckle rail have been developed.

Document SU-A-590390 discloses a deckle rail with channels for water flow in the inner edge of the deckle rail. The curved ribs define the direction of water flow through the channels for water flow between the deckle rail and the stock layer in order to reduce friction.

Documents FR 2128252 and US 5045154 disclose deckle rails with means for leading water from inside the deckle rail between the deckle rail and the wire for sealing the space between the deckle rail and the wire.

THE AIM OF THE INVENTION AND BRIEF DESCRIPTION

The main object of the present invention is to reduce or even to eliminate the problems found in the prior art described above.

The primary aim of the present invention is to eliminate significant shortcomings and problems related to current edge support, whereby the section of a paper or board web that corresponds to the edge areas can be improved in terms of

quality and in accordance with the operating values of the machine. The aim is to thus prevent the stock deficit caused by current technology and the leakage flow directed towards the edge of the wire in the edge areas of the web by extending the support of the deckle rail-type far downstream on the forming table. Such mechanical support requires, depending on the type of implementation, a reduction in friction between the stock and deckle rail by means of so-called lubricating water as well as the hydraulic sealing of the gap between the deckle rail and the wire by means of so-called sealing water.

An aim of the present invention is especially to achieve a paper or board machine, which produces paper or board of a better quality than before. It is also an aim to achieve a more economical and manageable edge support of a forming table in a paper machine. It is a further aim of the invention to achieve an arrangement, in which the surface friction between the stock and the edge support is lower than that of arrangements of prior art. Moreover an aim of the invention is to improve adjustability of the edge support.

In order to realise for instance the objects mentioned above the apparatus, method and paper machine according to the invention are characterised by what is presented in the characterising parts of the enclosed independent claims.

In this specification and in the claims the term paper machine is used in general terms. The term paper machine naturally also comprises board machines and other corresponding machines, which manufacture web from liquid containing stock.

A typical deckle rail of a forming table in a paper machine according to the invention comprises openings

- in the inner edge of the deckle rail facing the wire in order to lead water between the deckle rail and stock layer for the lubrication thereof and/or
- in the lower surface of the deckle rail in order to lead water directly between the deckle rail and the wire, for the sealing of the gap between the deckle rail and the wire with water.

In a typical method according to the invention in the paper machine stock is fed on the wire of the forming table of the paper machine to form a stock layer and the edges of the stock layer are supported by a deckle rail placed on the wire. It is also characteristic for a typical method that in the method water is transported inside the deckle rail and the space between the deckle rail and the stock layer is lubricated by leading water from inside the deckle rail between the deckle rail and the stock layer, and/or the gap between the deckle rail and the wire is sealed by leading water from inside the deckle rail between the deckle rail and the wire. In a typical method water can also be led outside the deckle rail, from where it can be divided by means of a manifold, hoses or branching pipe to different parts of the deckle rail, from where it is further led between the deckle rail and stock layer and/or deckle rail and wire. In connection with a method according to the invention no fabric edge curler is required, however, it can nevertheless be used.

BRIEF DESCRIPTION OF THE FIGURES

Figs. 1a and 1b show a conventional edge support of a forming table according to prior art,

Figs. 2a and 2b show the basic features of hydrodynamic edge support according to a first embodiment of the invention,

Fig. 3 shows a deckle rail according to a second embodiment of the invention,

Figs. 4a and 4b show a deckle rail according to a third embodiment of the invention,

Fig. 5 shows a deckle rail according to a fourth embodiment of the invention as well as dewatering,

Figs. 6a and 6b show transportation of water to the deckle rail according to a fifth embodiment of the invention, and

Figs. 7a and 7b show feeding of sealing water from the end of the deckle rail according to a sixth embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The embodiments and advantages mentioned in this text relate both to the apparatus, the method as well as to the paper machine according to the invention, where applicable, even though it is not always specifically mentioned.

The invention relates to an apparatus in a paper machine, which apparatus comprises at least one deckle rail for supporting the edge of the stock layer on the wire of the forming table as well as means for leading water to the vicinity of the deckle rail. A typical deckle rail of a forming table in a paper machine according to the invention further comprises openings or gaps in the inner surface of the deckle rail facing the wire for leading water between the deckle rail and the stock layer in order to lubricate this space and/or in the lower surface of the deckle rail for leading water directly between the deckle rail and the wire in order to seal the gap between the deckle rail and the wire with water.

According to an advantageous embodiment of the invention there are at least two deckle rails, one of which is typically in the machine direction on both sides of the stock layer arranged on the wire so that the stock layer can be supported on both sides. There can be for example 1, 2, 3, 4, 5, 6, 7, 9 or 12 deckle rails on both sides of the wire. In this application by supporting the stock layer can also be meant limiting the stock layer.

The deckle rail according to one embodiment of the invention can be made of plate, in which has been arranged openings or gaps by boring or otherwise. Openings arranged in the inner side of the deckle rail facing the wire for feeding lubricating water can have a diameter of for example 1 – 5 mm. When using elongated gaps the height of the gaps can be for example 1 – 2 mm. Openings arranged in the lower surface of the deckle rail for feeding sealing water can have a diameter of for example 3 – 10 mm. When using elongated gaps the height of the gaps can be for example 2 – 8 mm.

The inner side of the deckle rail facing the wire and the lower surface according to the invention can typically be of a porous material, the structure of which comprises a large number of small openings. When using a porous material the water flow is distributed particularly evenly on the entire surface area of the porous material. The surface of the porous material is easily kept clean and lubrication and sealing function particularly well.

The deckle rail can be made of ceramics, metal or plastic, for example.

The basic features of typical hydrodynamic edge support according to the invention are thus:

- The support does not normally involve fabric edge curler, i.e. lifting the wire up from the table, as fabric edge curler is not required in a solution according to the invention. Fabric edge curler is, however, possible to use in connection with a solution according to the invention.

- The support is based on an element like the deckle rail, which can also be called a hydrolimiter.

- The deckle rail comprises openings in the inner edge surface of the deckle rail facing the wire for leading the water between the deckle rail and the stock layer in order to lubricate this space and/or in the lower surface of the deckle rail for leading water directly between the deckle rail and the wire in order to seal the gap between the deckle rail and the wire with water.

- Dewatering extends at least substantially to the entire width of the web. Advantageously the dewatering only extends to the inner surface of the deckle rail, whereby dewatering does not take place from underneath the rail, and thus the required amount of sealing water remains low and easier manageable. It is, however, possible to extend the dewatering underneath the deckle rail.

The greatest improvements to current paper machines equipped with flat forming tables which can be attained with the aid of a deckle rail according to the invention, which also can be called a hydrolimiter, are:

- The width of the machine can be nearly maximally utilised because of the very small edge disturbance. Typically, depending on each case, a 10-60 cm wider web than at present of good quality can be attained.

- Due to smaller edge disturbances web breaks decrease.

- Dewatering is directed evenly on the entire width of the web all the way to the deckle rails. Thus smaller discrepancies in basis weight and more even drying properties are achieved.

- As the wire does not need to be lifted by its edges, there is less strain on the wire.

- The function of the deckle rail can be adjusted by changing the flows of its lubricating water. Differing from current edge support and its difficult adjustability the function of the deckle rail according to the invention can easily be adjusted also as an operation when the machine is running. Quality specific adjustments to the deckle rail for different products can be arranged, if necessary, to function automatically and can be advantageously realised as a flow adjustment.

- Means for feeding water can be arranged at the end of the deckle rail in the machine direction and according to possibility at machine speed as well as at the thickness of the stock layer. Water fed in this manner supports the stock layer after the end of the deckle rail and prevents the stock from spreading out towards the outer edge of the wire.

Advantageously the deckle rail is long, extending almost from the head box almost to the dry line. The deckle rail or a combination of deckle rail elements can regarding its length be for example 30-100 % of the length of the forming table, advantageously 50-99 % of the length of the forming table. An

arrangement according to the invention can for example start immediately at the end of the forming table or at a distance of about 1-50 cm therefrom. The arrangement can likewise end at the dry line or in the vicinity thereof.

As paper machines are individual, different embodiments of the central element of the hydrodynamic edge support according to the invention, the deckle rail, are conceivable. Certain such separately or as combinations implemented solutions are:

a) The deckle rail is long, extending to such a measure, in which a remarkable part of the dewatering of the table has occurred and there is a filtered layer on the wire, which layer also can be called a fibre layer as the relative fibre content of the layer has remarkably grown, as a consequence of dewatering.

b) The deckle rail functions as a channel for lubricating and sealing water.

c) The gap between the deckle rail and the wire is sealed with sealing water, whereby the sealing is achieved in the manner of a hydrodynamic sealing by bringing underneath the deckle rail water having a smaller pressure loss and therefore a leakage flow towards the stock layer. Sealing water can be brought through suitable openings from inside the actual deckle rail. There can be arranged on the lower surface of the deckle rail lamella or the like for creating suitable pressures and flows. The lower surface of the deckle rail can be of a porous material, structure of which comprises a large number of small openings. Naturally also other manners of feeding sealing water are possible.

d) The inner surface of the deckle rail is fed with ~~sealing~~lubrication water, by means of which the surface is kept clean and the surface friction low. Thus the boundary layer forming on the surface of the deckle rail is thin and the disturbance extending to the web insignificant. This is an especially important feature when

the deckle rail extends near the dry line. The lubricating water can, for example, be brought through suitable openings from inside the actual deckle rail in the manner as described below in more detail by the figures. The feeding openings can be on the inner surface of the deckle rail, whereby the lubricating water is effectively fed directly between the deckle rail and the stock layer. The inner surface of the deckle rail can be for example of a porous material, the structure of which comprises a large number of small openings. Naturally also other manners of feeding lubricating water are possible.

e) The filtered layer forming on the wire and the flow resistance thereof can be used for sealing the gap between the lower surface of the deckle rail and the wire, especially at the last section of the deckle rail. Increasing the gap between the deckle rail and the wire relative to the thickness of the filtered layer is used as implementation. In some cases a simple sealing plate or sealing arranged on the outer edge of the rail can be utilised as well.

According to the invention the inner surface of the deckle rail is kept clean and the surface friction low with the aid of the lubricating water. Consequently the stock layer hardly attempts to stick to the surface of the deckle rail.

The deckle rail according to the invention can be formed by one long element or it can be formed by several shorter elements connected to each other. Connecting the elements to each other can be performed by any per se known method to someone skilled in the art. The function of the deckle rail according to the invention can vary in different locations, for example the amount of lubricating water to be fed can differ according to need in different parts of the forming table. An advantageous deckle rail according to the invention is substantially parallel or as parallel as possible with the travel direction of the wire. Thus, the formation of edge waves can be minimised.

The invention also relates to a method in a paper machine. In a typical method according to the invention in the paper machine stock is fed on the wire of the

forming table of the paper machine to form a stock layer and the edge of the stock layer is supported by at least one deckle rail placed on the wire. It is also characteristic for a typical method that in the method water is brought inside the deckle rail and the space between the deckle rail and stock layer is lubricated by leading water from inside the deckle rail between the deckle rail and the stock layer, and/or the gap between the deckle rail and the wire is sealed by leading water from inside the deckle rail between the deckle rail and the wire.

According to an embodiment of the invention the lubricating water is led through the inner edge of the deckle rail facing the wire directly between the deckle rail and the stock layer, whereby the advantages described above and below are attained.

According to another embodiment of the invention the sealing water is led through the lower edge of the deckle rail facing the wire directly between the deckle rail and the wire.

According to yet another embodiment of the invention water from the end of the deckle rail is fed substantially in the machine direction in order to support the edge of the stock layer arranged on the wire.

The invention also relates to a paper machine comprising a forming table which is characterised by an apparatus according to an embodiment of the invention in connection with the forming table.

Advantageously the means for bending the edges of the wire upwards are lacking from the forming table of such a paper machine, that is as the arrangement described above is used, there is no need to bend the edges of the wire upwards. In connection of the forming table there can be means for bending the edges of the wire upwards and the edges of the wire can be bent upwards, if it is considered necessary.

The invention is described in more detail below with reference to the enclosed schematic drawing.

DETAILED DESCRIPTION OF THE FIGURES

In figures 1a and 1b an arrangement according to prior art is shown, which has been described above, i.e. conventional edge support of a forming table.

Figures 2a and 2b show the basic features of hydrodynamic edge support according to the first embodiment of the invention. In figure 2a an arrangement is shown according to an embodiment of the invention as seen from above. The arrangement comprises a head box 1, a wire section 6, a dewatering area 7 and a deckle rail 8 according to an embodiment of the invention. In figure 2b a section of the arrangement in figure 2a is shown as seen from the end, and in particular the deckle rail 8 and the wire 5 have been depicted therein.

In figures 2a and 2b it is shown a basic feature of typical hydrodynamic edge support according to the invention, that is that the support does not include fabric edge curler, that is raising the wire from the table, but is based on an element such as the deckle rail.

The deckle rail shown in figure 2a is long extending to such a distance from the head box, that a significant part of the dewatering taking place on the forming table has been effected and there is a filtered layer of paper or board stock on the wire.

Figure 3 shows a deckle rail according to a second embodiment of the invention and the rail/laminated structure thereof as well as the use of sealing water for sealing. In this solution the deckle rail 8 functions as a channel for lubricating water (indicated by arrows 9) and the gap between the deckle rail 8 and the wire 5 is sealed by sealing water. Also stock 10, which can be paper or board stock, is schematically shown in the figure. Sealing is achieved in the fashion of a hydrodynamic sealing by bringing underneath the deckle rail 8 water having a smaller pressure loss and therefore the leakage flow towards the stock layer 10. Advantageously the sealing water is brought in the manner shown in Figure

3 through suitable gaps from inside the actual deckle rail 8. In this embodiment the lower surface of deckle rail 8 has lamellas 11. By using lamellas 11 of different heights, the gap between the deckle rail 8 and the wire 5 can be altered and thus suitable pressure and flow conditions can be achieved.

Figures 4a and 4b show a deckle rail 8 according to a third embodiment of the invention and an example of how the surface of the deckle rail 8 is kept clean with sealing water 12 according to the invention and surface friction low in relation to the non-lubricated flow. Consequently, the stock layer 10 hardly attempts to stick to the surface of the deckle rail 8.

Even in this embodiment the deckle rail 8 functions as a channel to sealing water (shown schematically by arrow 12). Figures 4a and 4b describe the situation in the last section of the deckle rail 8, in which for sealing the gap between the lower surface of the deckle rail 8 and the wire 5 a filtered layer 13 formed on the surface of the wire 5 and the flow resistance thereof can be used. Additionally the figures show the stock 10 on the filtered layer 13. In an embodiment according to figure 4a the feeding openings for sealing water are arranged on the inner surface 14 of the deckle rail 8, whereby the lubricating water 12 is efficiently fed directly between the deckle rail 8 and stock layer 10. In figures 4a and 4b also lubricating water layer 16 and the lamellas 11 on the lower surface of the deckle rail 8 are shown.

In figure 4b yet another alternative embodiment has been shown, in which the gap between the deckle rail 8 and the wire 5 has been increased relative to the thickness of the filtered layer 13. In the embodiment of figure 4b the inner surface 14b of the deckle rail is of a porous material, the structure of which comprises a large number of small openings. While using a porous material the feeding of lubricating water 12 is distributed particularly evenly and the inner surface 14b of the deckle rail is kept very clean.

A deckle rail 8 and a suction box 17 for dewatering according to a fourth embodiment of the invention are shown in figure 5. In the example according to the figure suction box 17 ends at the inner line of the deckle rail 8, so that

dewatering does not take place from underneath the deckle rail 8, whereby the amount of sealing water can more closely be controlled and it easily remains low. In solutions according to prior art dewatering extends often outside the line defined by the deckle rail.

Figures 6a and 6b show an example according to a fifth embodiment of the invention of how the transport of water to the deckle rail 8 can be arranged. In the example in Figure 6a water is transported to the deckle rail 8 by a tube 18a, which has branches 18b. In the example in the Figure 6b the tube 18a has a bypass manifold, from which water flows along hoses 18c to the deckle rail 8.

Figures 7a and 7b show the feeding of sealing water 19 at the end of the deckle rail 8 according to the sixth embodiment of the invention. Sealing water 19 is fed substantially in the machine direction and according to opportunity at machine speed for supporting the edge of the stock layer 10 on the wire 5. A raised deckle rail 8 according to Figure 7b is particularly well suited to a situation where the filtered layer 13 on the wire 5 is significant. In the example of the figure the lower edge of the deckle rail 8 ends at a point, where sealing water 19 is fed. The upper edge of the deckle rail 8 continues further forward from the feeding point of sealing water 19, which solution can be called a raised deckle rail. According to the example of the figure the thickness of the filtered layer grows in the machine direction at the same time as the stock layer becomes thinner. Only advantageous embodiments according to the invention have been presented in the Figures. It is apparent to someone skilled in the art that the invention is not limited exclusively to the examples described above, but that the invention can vary within the scope of the claims presented below and what has been disclosed in the specification. The dependent claims present some possible embodiments of the invention, and they are not to be considered to restrict the scope of protection of the claims as such. Also the reference numbers are not to be considered to restrict the scope of protection of the claims. Further the verb "comprise" is to be interpreted as open.